A Laparoscopic Update

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Henry Yokoyama asked me in late 1997 to write an article on laparoscopy. Hoping that our medical colleagues might be curious about what goes on in the inner sanctum of the operating rooms, I agreed. The articles that you'll be reading are a result of my pleas to my surgical colleagues and are included in this issue. Robb Ohtani was ambitious enough to gather the gynecologists together for their contributions which will be published in early 1999. I selected the group of general surgeons because of their expertise or special interest in their subject. I thank them all.

In the following articles, we'll be taking a look at some of the procedures that have been adapted to laparoscopy. I'm sure there will be some surprises for everyone. Even the general surgeon accustomed to performing laparoscopic colectomies may be unaware of the advances occurring in gynecology. For the non-surgeon, I hope that these articles will improve awareness of what conditions the laparoscopists can now treat.

First, we need a perspective. A study of laparoscopy's roots might be if interest to you. It is a fascinating story, replete with ingenuity, innovation, inspiration, and luck. Let us begin.

The events of the past 10 years have been a great surprise to me. No one could have anticipated how far laparoscopy would come. I am not embarrassed to admit that I was a disbeliever of its potential. In 1989, I recall reading the article by Drs. Eddie Reddick and Olsen in Surgical Endoscopy reporting their first cases of cholecystectomy done with the laparoscope. I was amused. Why would any sane surgeon struggle with a cumbersome, albeit new, method when the old way was so simple, safe, and reliable? At the Hawaiian Surgical Association meeting on the Big Island, I had to personally speak with Dr. Reddick and view his videotape of this new procedure before I was convinced. How ironic that now ninety-five percent or more of cholecystectomies are done laparoscopically. I had learned an important historical lesson.

In August of 1991, the first laparoscopic cholecystectomies were done in Honolulu. Seven of us (Virginia Pressler, Steve Nishida, Peter Halford, Werner Grebe, Kristine Gebrowsky, Mihaç Yu, and myself) began at the Queen's Medical Center. Gene Robinson started at Pali Momi. I think I can speak for all in saying that those first cases were some of most challenging, satisfying, and stressful cases of our careers.

Many have called the advancements in laparoscopy in the early 1990's a revolutionary period in general surgery. Studying the history of laparoscopy, however, makes it clear and fascinating that most pioneers are merely the most recent on a timeline of innovators and each is interdependent on many others for his individual successes. Each advance was the endpoint of an accumulation of human invention and is really evolutionary. While one person may be credited with having been the first to have accomplished an act, more often than not, many had thought about doing it before him but lacked only another concept or instrument, ever so slight or simple.

Having never inserted a Veress needle into an abdomen, many of us implored our gynecology friends to show us how to do it. This needle allowed the abdomen to be inflated with carbon dioxide, creating a cathedral-like work space. Janos Veress, by the way, was a Hungarian physician who, in 1938, reported his invention of a spring loaded obturator that slipped beyond the sharp point of the needle, lessening the chance of perforating a viscus. He never anticipated that his needle would be used to our benefit in 1991; he devised it to drain ascites and pleural effusions and never suggested that it be used to insufflate air.

Kelling, a German, about 1900, was the first to use a (sharp) needle to instill room air into the abdomen, which he viewed with a cystoscope. No one thought much of this idea at the time. Perhaps this was because his subjects were dogs. Hans Christian Jacobaeus of Stockholm, Sweden was the first to report in 1910 on the use of laparoscopy and thoracoscopy in humans. He instilled air through the trocar. He felt that thoracoscopy held greater potential and pursued this in the treatment of tuberculosis, leaving further developments in laparoscopy to others. Eventually, endotracheal intubation would enable formal thoracotomy to overshadow thoracoscopy, until, of course, today, when thoracoscopy has regained some respect. That story is for another editor to tell.

Air, though abundant, was not easy to work with. It enabled combustion and tended to leak out of the trocars. Richard Zollikofer of Switzerland suggested carbon dioxide as the ideal gas. It was non-flammable and was quickly absorbed by the peritoneum. Not everyone listened to Richard. In 1933, C. Fervers in Germany used oxygen to insufflate the abdomen, which resulted in a flash explosion when cautery was used to lyse adhesions. The patient survived, but the use of oxygen as a method of pneumoperitoneum did not. Z.E. Stone of Kansas in 1924 described the use of a rubber gasket placed at the end of the trocar to reduce the air leak.

In 1991, we were using the Veress needle, carbon dioxide, and Dr. Stone's rubber gasket to insufflate our patients' abdominal cavities.

Once the abdomen was filled with carbon dioxide, a sharp pyramidal tipped obturator within a (hollow) trocar was blindly plunged through the linea alba. This daring act consistently confirmed my belief in the benevolence of the universe. B. H. Orndoff of Chicago in 1920, invented that horrendous instrument, whose sharpness simplified the insertion of the trocar but likewise increased the chance that bowel or aorta might be punctured. Orndoff used fluoroscopy as an aid to insertion. In later months, many of us would learn the open technique of trocar placement developed by H. M. Hasson whereby a blunt trocar was inserted under direct vision. Hasson thought of this method 20 years before, in 1970, and greatly reduced the degree of faith and the intensity of prayer required to begin the operation.

Through the 10 mm trocar, we inserted the tubular rod-lens scope, a marvel of optical engineering, which gave us a bright light and a clear image. Life was not so simple before this.

The Ancients did not have the benefit of modern glass and metals technology. Writings from 400 BC to 1000 AD in Greece, Pompeii, Rome, Babylonia, and Baghdad described various primitive tubes and speculums used to exam the various orifices the human body. Getting a tube into those orifices was an accomplishment in and of itself, but seeing through that tube required that another set of engineering dilemmas be solved.

One needed light to see. Many instruments were devised using both natural and artificial light, directed through holes, flasks, lenses, and mirrors. Philipp Bozzini working in Frankfurt in the early 1800's, developed the first practical endoscope using a candle, mirrors, and different specula to view the urethra, bladder, rectum, and vagina. Medical conservatism, politics, and professional jealousy hindered its acceptance by his colleagues.

Up through the 1850's, subsequent scopes using similar principles were constructed by Segalas (in Paris), Fisher (in America), and Desormeaux (in Paris). All suffered from poor external lighting and a view limited by the narrowness of the tube-speculum.

The urologist Maximillian Nitze is often credited with inventing the first "modern" cystoscope. Nitze collaborated with both an optician and an instrument maker (Josef Leiter), producing a scope in 1880 whose lens system gave a wider field of vision and a magnified, non-inverted image.

His initial light source was a heated platinum wire, placed at the tip of the scope and cooled by water (easily done in the bladder). Putting the light source within the bladder was a great inspiration, but he apparently borrowed that idea from a dentist, Julius Brock, who 13 years before had used the platinum wire light to view the inside of the mouth.

About the same time, Thomas Edison, aided by Perspiration, had invented the incandescent bulb (in 1879). Leiter meanwhile feuded with Nitze, and they parted ways. In 1883, Newman in Scotland passed a miniaturized bulb into the bladder through a cystoscope. By 1887, both Nitze, a German, and Leiter, an Austrian, independently had connected the American's invention to the tip of a cystoscope. The scope that Nitze (and Leiter) created remained conceptually unchanged until the 1960's.

Though the Nitze scope was revolutionary, it still suffered from relatively poorly light transmission characteristics: the view was dim. Pressured by a urologist, James Gow, Professor Harold Hopkins, an Englishman, invented the rod-lens scope, a system mass produced in the 1960's by a German instrument maker named Karl Storz. For those uninformed internal medicine types, this man Storz is to surgical instruments what Levi Strauss was to pants.

In Nitze's scope, a series of lenses was placed within an air-filled tube. At each air/glass interface, light was reflected. Light absorbed by the interior of the metal tube was also lost. Both effects reduced the amount of light reaching the eyepiece. In a brilliant conceptual maneuver, Hopkins reversed the materials within the tube. In place of air spaces, he inserted solid glass rods, curved at their ends, and separated by narrow air pockets, creating in effect, air lenses. This arrangement exploited the phenomenon of internal reflection of light within a glass tube and, combined with the new technology of antireflective lens coatings, increased the light transmitted by a factor of 80. Our current scopes bear the name of "Hopkins."

We are still left with the major problem of getting enough light with which to see into the abdomen. The heat generated by an incandescent bulb placed at the tip of a scope would be obviously damaging to tissues. Once again, enter Professor Hopkins.

In the 1940's, the decade before he developed the rod-lens system, Hopkins was stimulated by the gastroenterologists' need for a flexible scope to replace the rigid scopes of that era. He and a graduate student constructed a primitive short flexible tube which consisted of fine glass fibers, bundled and oriented to carry an optical image. They named it the "fiberscope." Hopkins moved on, directing his energies to the rod-lens scope, but from this primitive instrument came the next piece of the technical puzzle.

Basil Hirschowitz, a fellow in gastroenterology at the University of Michigan read of Hopkins' work, and collaborated with two physicists (Peters and Curtiss). They coated fine glass fibers with a glass of lower refractive index to exploit the phenomenon of internal reflection, and in 1957 built the first practical flexible gastroscope. The light source of these early scopes was still an incandescent bulb placed at the tip of the scope, but by 1963, a fiber optic cable, based upon the glass fiber concept of the flexible gastroscope, was carrying light from an external source. This was a "cold" light which eliminated the risk of heat injury to internal organs.

Over the next 15 years, Dr. Kurt Semm, a German gynecologist took the advances in scopes and light sources and performed a variety of gynecologic procedures endoscopically (adhesiolysis, ovarian biopsy, fimbriolysis, tubal sterilization, salpingectomy, oophorectomy, myomectomy). He was the first to perform an appendectomy, incidentally, of course, and to suture the bowel. To accomplish this he developed a number of instruments and concepts which we still use today: high frequency monopolar and bipolar coagulation, the automatic pressure regulating insufflator, the hook scissors, a uterine vacuum grasper, a tissue morcellator, the endoloop, the suction-irrigating tubing, endosuturing, and the "pelvitrainer," an apparatus to aid surgeons in developing the hand-eye coordination necessary for laparoscopic operations. He was prolific inventor.

In 1991, to complete our cholecystectomies, we were using the still relatively primitive tools developed by Semm and the gynecologists.

American surgeons, meanwhile were doing little to advance laparoscopy in the 1960's. "Culdoscopy" was devised by two Americans Decker and Cherry, and was the most popular technique up to the 1960's. This arcane and undignified procedure had the woman positioned on her hands and knees. The few laparoscopists performed only minor diagnostic procedures such as liver and organ biopsies, ascites drainage, and minor gynecologic procedures on the tubes and ovaries, mainly tubal ligations. Even with Semm and the Europeans pushing the laparoscopic envelope, the clumsiness of the laparoscopic instrumentation dissuaded most American surgeons from embracing the technique.

The accomplishments of Semm and his contemporaries are remarkable when one considers that they viewed the abdomen through the single eyepiece of a rigid scope. When the scope was moved to another angle, so had to move the surgeon's head. Any observer had also to look through an eyepiece physically connected to the surgeon's scope. A cumbersome articulated optical tube system was still being used by gynecologists as recently as 1991. For the surgeon to use two hands, the assistant had to hold the operating scope/eyepiece for him, while holding his own eyepiece merely to observe the procedure. He could not provide any operative assistance. This obviously limited the complexity of the procedures which could be performed.

Our generation of pioneers were waiting for the marvelous CCD.

You are undoubtedly familiar with the silicon charge-coupled device (CCD). Your home video camera uses it to capture a light image, converting it into electrical impulses, which are then recorded onto magnetic tape. The CCD was developed at Bell Laboratories in 1969, but it took grants from NASA to nurture its development into the compact and light weight camera we use today. The chip itself is smaller than a postage stamp. The first practical camera was marketed by Circon in 1985. Its resolution is not as great as the cameras now on board the Galileo space probe (to Jupiter) or the Hubble telescope or the Cassini probe (to Saturn), but it uses the same technology. The arthroscopists were quick to exploit its potential and were the first to use the technology here in Hawaii.

The CCD camera sits atop the eyepiece of the laparoscope. It is about 7-10 cm long and connects by a cord to a video processor which transmits the image to a familiar black box, the TV monitor (now that is a fascinating story and an important part of the puzzle as well). We now had a large, clear, bright, color image which could be viewed by many observers. This video-imaging system freed the surgeon to use 2 hands to operate and enabled assistants to participate actively in the operation.

By 1987, the first cholecystectomies in humans were performed using the CCD-TV systems, first in France and then in the United States. In early 1991, Eddie Reddick in Nashville was teaching his technique to a small group of Hawaii surgeons. He normally charged $3,000 dollars to take his course. He offered it to us for free. Dr. Reddick had been a surgical resident at Tripler and most of us had been his instructors. The student had now surpassed the teachers.

Our first laparoscopic cholecystectomy adventures were made possible by the cumulative daring and ingenuity of the many inventors before us. Soon we became familiar with the instrumentation. Laparoscopic cholecystectomy became routine. A few gynecologists confided to me that the general surgeons' success stimulated them to perform more complex procedures. It was inevitable that appendectomy and inguinal herniorrhaphy would be adapted to the laparoscope.

It has been an intoxicating ride. As I look back upon our first entry into laparoscopic surgery in August of 1991, I find it hard to recall how difficult it seemed then. As you will see in the forthcoming articles, technical advances have made more difficult operations feasible (colectomy, splenectomy, adrenalectomy, fundoplication, nephrectomy, and others) and have simultaneously raised issues of cost, safety, and efficacy. What lies ahead? If I've learned anything from the past seven years, it is that the unimaginable will become possible. History teaches us that the horizon is never fixed.

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